Green Manufacturing Initiative and Green Manufacturing Industrial Consortium

Western Michigan University
Green Manufacturing Research Center
John Patten, Dave Meade, Matthew A. Johnson and Michael Barcelona

2nd Annual Michigan Green Chemistry Conference 2010
Lansing, Michigan

Overview

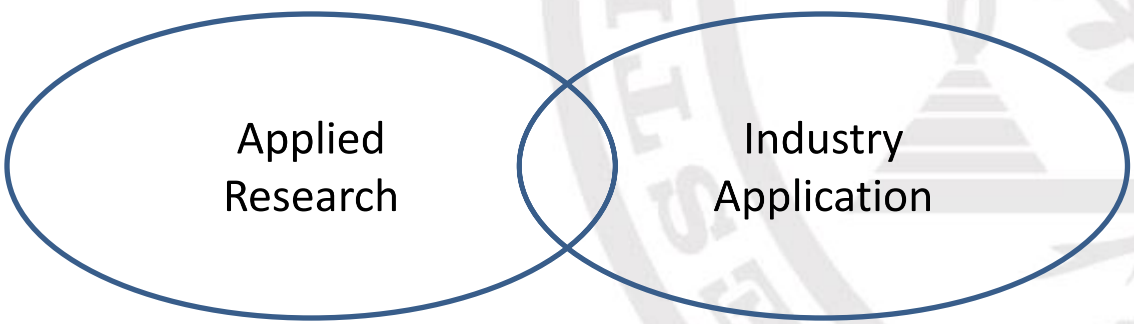
- Background of the Initiative
  - History of Concept at WMU
  - Founding and DOE Grant
  - Purpose of the Initiative
- Green Manufacturing Initiative Consortium
  - Structure and Members
  - Benefits
- Case Studies
  - Highlight of recent projects

Brief History

- Concept developed in 2003 at WMU.
  – Gained traction and received interest from industry.
  – In 2010, Rep. Fred Upton and Senators Stabenow and Levin, the idea received funding through the U.S. Department of Energy.
    - $1 Million in funding.
  – Funds used to develop the Green Manufacturing Initiative and Consortium.
  – Director of the Green Manufacturing Initiative
    - Dr. John Patten, Department Chair of Manufacturing Engineering.

Focus of Initiative

- To provide a conduit between the university and industry to solve green (sustainable) manufacturing related problems.
- Conduct internal research in key university focus areas.



Our Philosophy

Environmental (benign)

+

Energy (conscious)

+

Economical (viable)

Green Manufacturing Initiative
Pursuing Environmental, Energy and Economic Opportunities

The Green Team

- College of Engineering and Applied Sciences
- College of Arts and Sciences
  - Biology
  - Chemistry
  - Geology
- College of Business

Green Manufacturing Initiative Consortium (GMIC)

- A mechanism to catalyze partnerships among industry, academe, and government.
- Based on National Science Foundation’s (NSF) model .
  - Industry/University Collaborative Research Center (IU/CRC)
- Chair of GMIC
  - Dr. David Meade, Associate Professor of Manufacturing Engineering

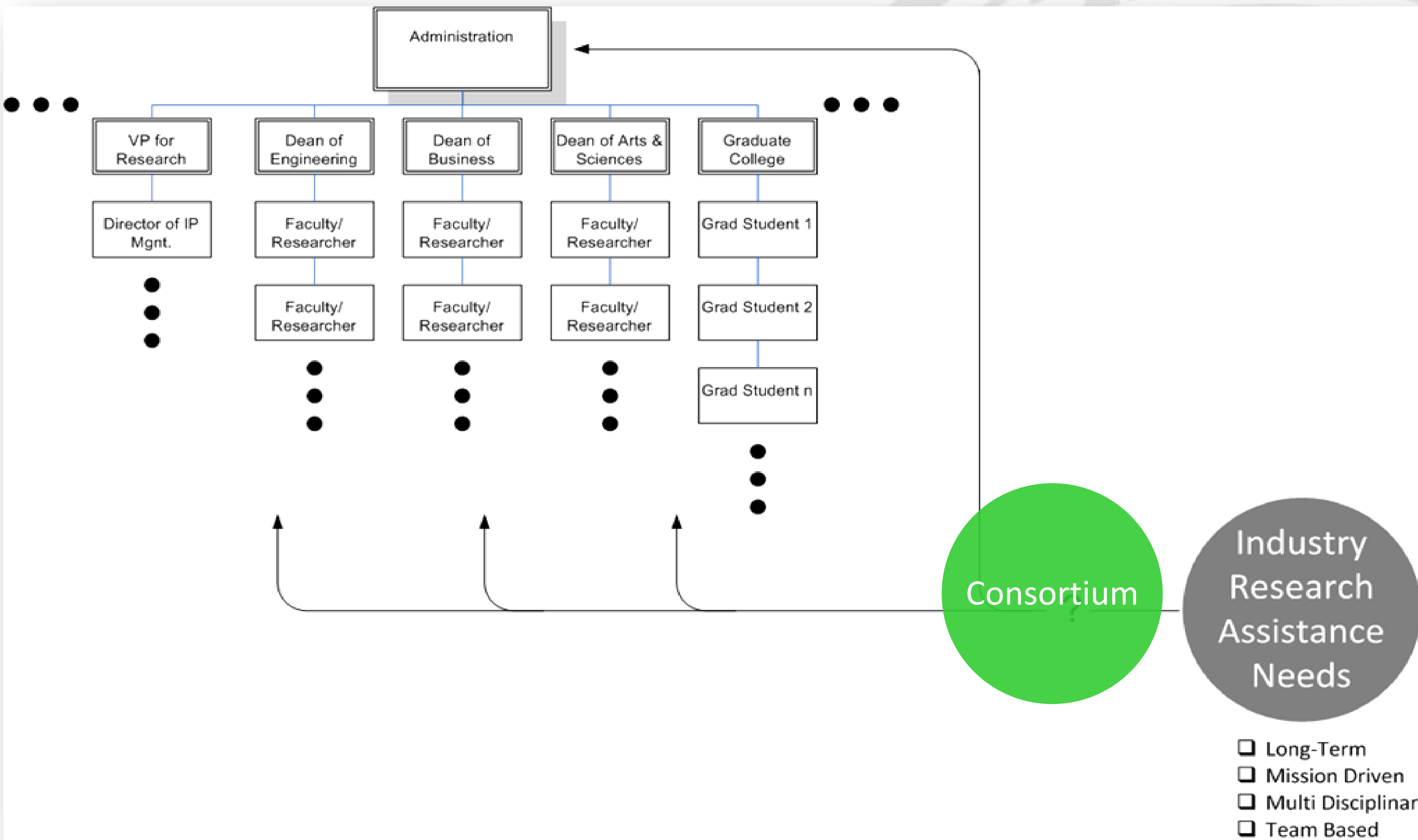
Vision of GMIC

- The Green Manufacturing Industrial Consortium (GMIC) is a university-industry based research collaborative comprised of Western Michigan University (WMU) faculty, students, and staff, and ***10-30*** industry partner companies.
- WMU will work with GMIC partners (industry) to ***improve (i.e. reduce) the environmental and energy impact of their designs, materials, processes, and facilities***, including end use of their products through the end of the product lifecycle.
- Projects accomplished through leveraging the industrial partners ***experience and resources*** and the university's ***technical expertise and research facilities***.

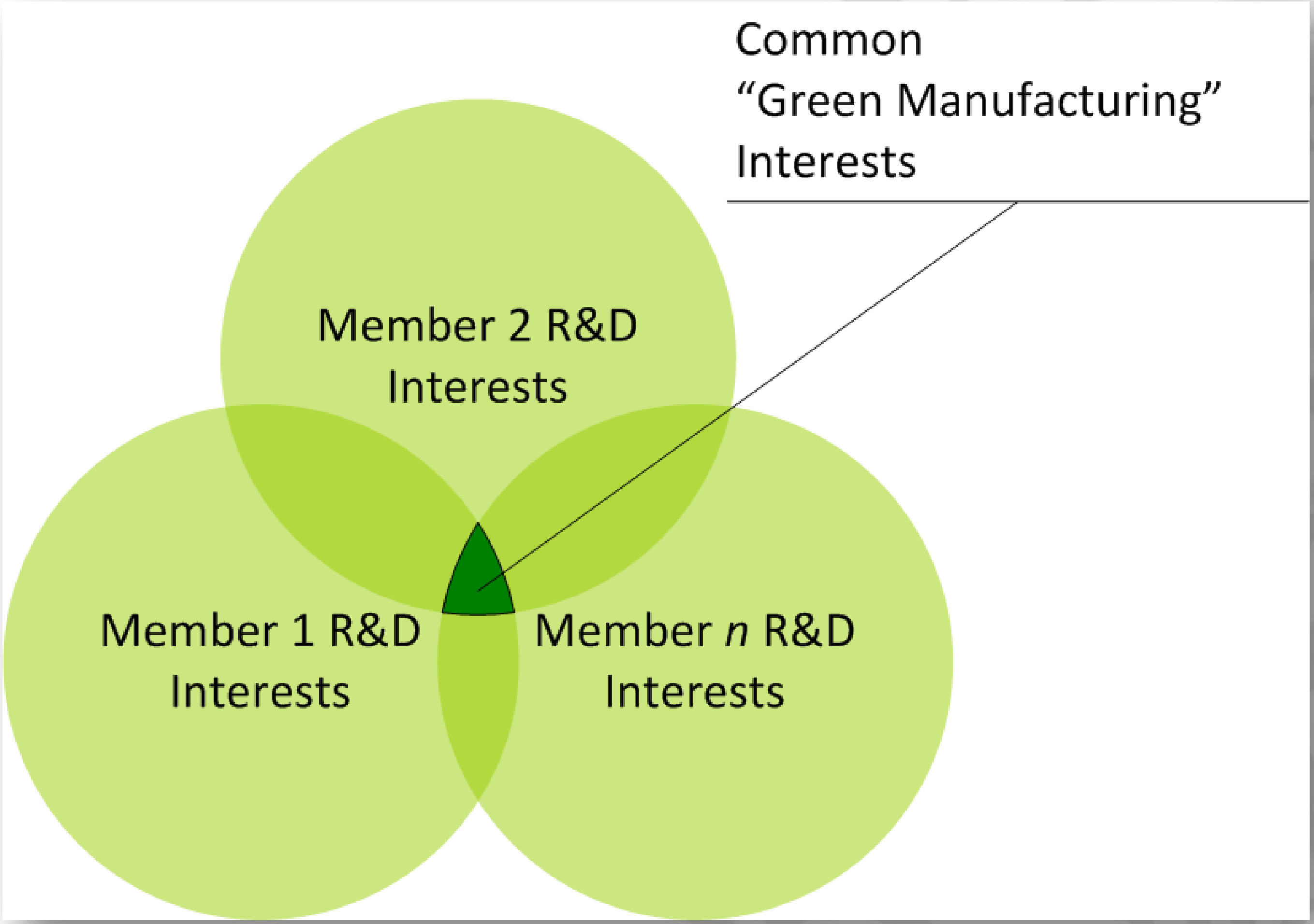
Mission

- The Green Manufacturing Industrial Consortium (GMIC) has two focuses:
  1. To support advancement in manufacturing practice through the creation of more energy efficient and environmentally benign processes and products while enhancing productivity and sustaining or increasing output.
  2. To provide a forum for manufacturers to coordinate research and share results, while leveraging R & D funding, at the pre-competitive stage.

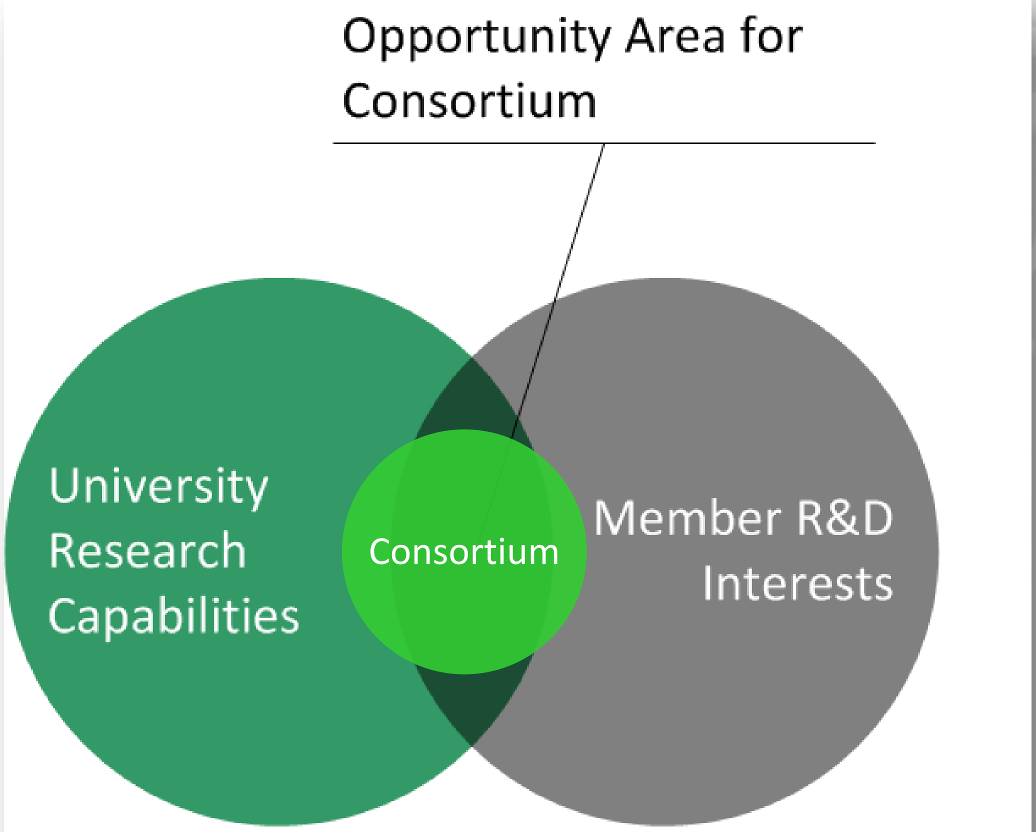
What problem is the consortium trying to solve?



Existing industry efforts and/or needs



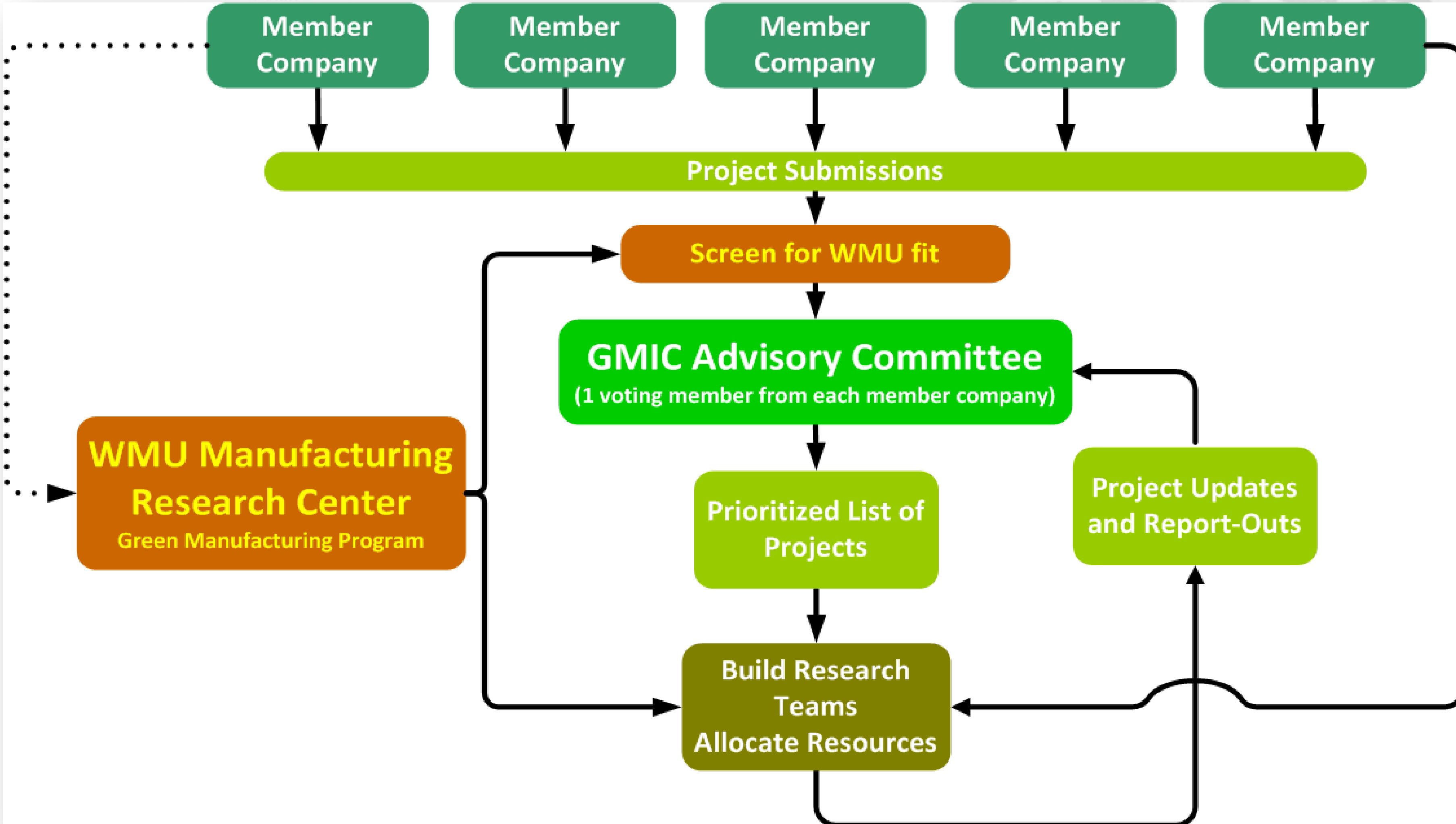
GMIC- 'The Focal Point'



- ❑ Laboratory
- ❑ Equipment
- ❑ Tools/Software
- ❑ Personnel
- ❑ Experience

- ❑ Materials
- ❑ Process
- ❑ Product Design
- ❑ New (Green) Technologies

Project Selection/Execution Process



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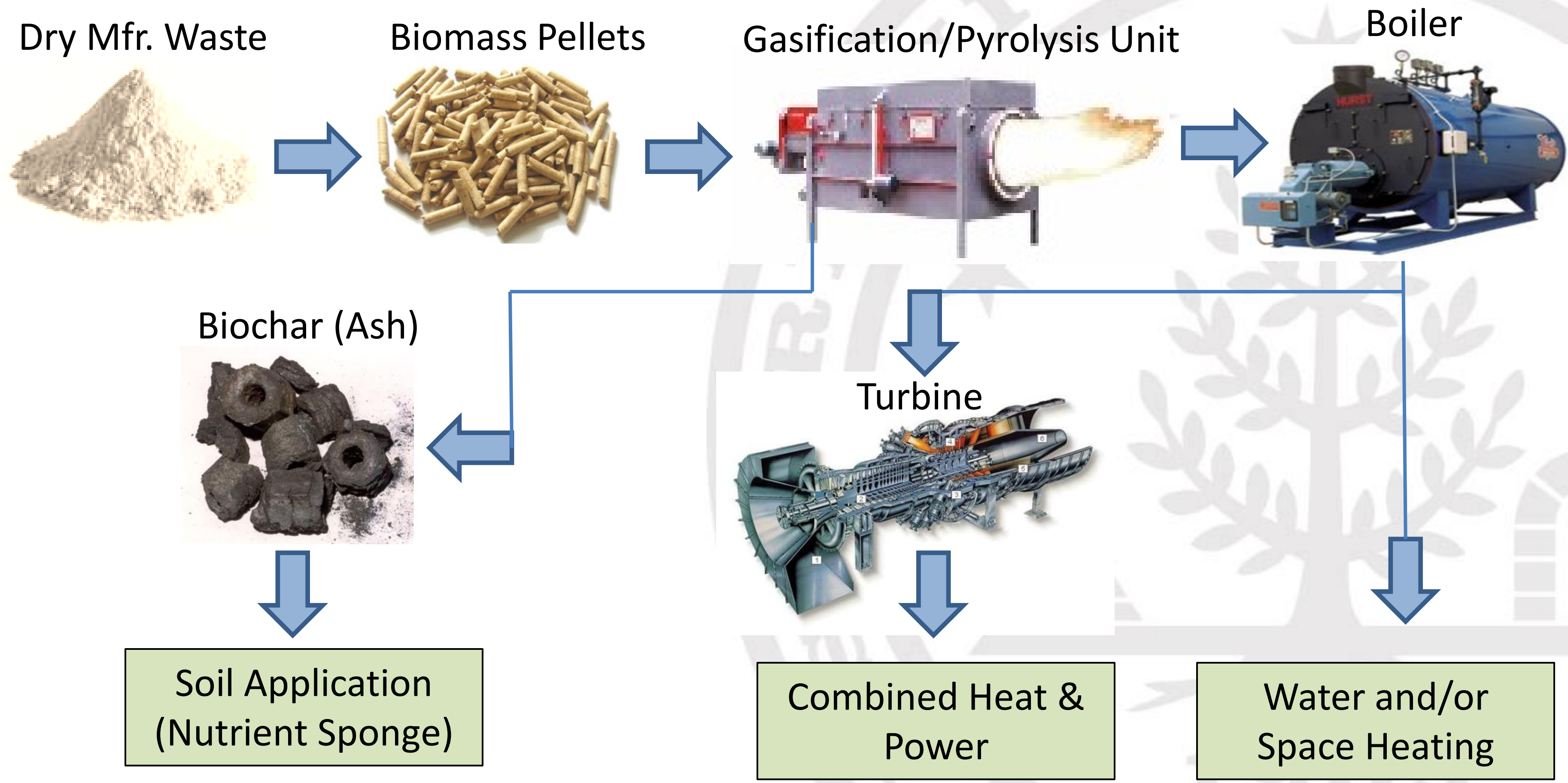
Membership

- 5-Year “commitment” (non-binding)
- $25,000 annual membership dues
- Signed Memorandum of Understanding (MOU)
  - Ownership and management of Intellectual Property
- Member developed bylaws
  - Project selection procedures
  - New member induction process

Case Studies

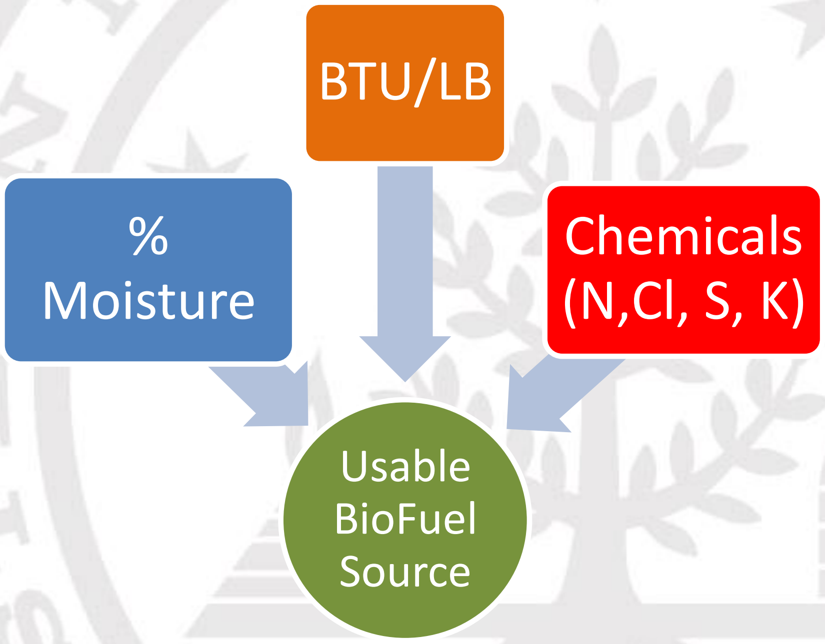
- Since January 2010, GMI has undertaken various projects with companies in West Michigan.
  - Waste-to-Resource- Bio
  - Facility Energy (Bio/Renewable)
  - Facility Efficiency
  - Coatings Research
  - LEAN Manufacturing

Waste-to-Resource
Biomass Pellet (Food Waste) Fuel



Waste-to-Resource Biomass Pellet Fuel

- Biomass Fuel Source
  - Manufacturing food waste
  - Primarily processed hydrocarbons
- Financial Cost: $1.36 million
- 10-Year NPV: $5.69 million
- IRR: 53%
- 3.12 year payback
- Project at pilot testing phase.



Waste-to-Resource Anaerobic Digestion

- Erdman Machine's Goal
  - 100% of operation running on energy produced onsite
- Current
  - Anaerobic digester
    - w/ flare
  - OOC waste water treatment plant
  - Design for biodiesel plan
- Bio Feedstock Available
  - Meat shavings & fat
    - 75% Solids
    - Beef, chix, pork
  - Garlic butter byproduct
    - 40% solids
  - Cheese mfg. byproduct
    - 25% solids
  - Cow/pig manure
    - Goal: 10-15% solids

Waste-to-Resource Anaerobic Digestion

- Biogas can offset
  - NG
- Digestate can offset
  - Fertilizers
- Biodiesel can offset
  - Petroleum diesel, electricity, heating fuels

- Project is currently in the system design phase.
- Digester Equilibrium
  - Optimum feedstock blend [TVS/Gal]
  - Feed Rate [Gal/day]
  - Turnover Rate [#/day]
  - Retention Time [Days]

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Evaluation, Optimization and Re-Design of a Forklift Fleet

- Worked with company to evaluate a combined renewable energy/electric forklift project.
  - Replaced fleet with smart chargers and new batteries.
  - Provided cost analysis for 20% renewable energy to the forklifts.
  - Conducted energy analysis studies on forklifts in operation.
  - Operators were retrained to be more efficient.
  - Batteries and Chargers
    - Initial Investment: $33K
    - Return: $29.5k/year
    - Simple Payback: 13 months

- Solar/Wind energy
  - Initial Investment: $56k
  - Simple Payback (Comb.): 3 years

Autophoretic Coatings

- Researching alternative pre-treatments to improve corrosion resistance.
  - To reduce the amount of coating used by 50%.
- Most autophoretics are PVC-based currently.
  - An environmental concern.
  - Investigating alternatives.

Reduce → Improve → Eliminate

Reduce the environmental impact of the companies hexavalent chromium plating operations.

- Provided plans to decrease hazardous waste stream by 97% by reducing the amount of solid and chemical chromic acid waste coming from their process.
  - Chemical remediation.
  - Contamination prevention.
  - Work center design.
- Proposed heat cycling plan of the plating tanks to reduce energy consumption by 53%.
  - Total projected savings of $5000.00/annually and 1.5 year payback.

“Greening” the Chrome Plating Industry: Case Study

Matthew Johnson
Western Michigan University

$\mu g/m^2$

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Why the concerns?

- Environmental and Health Concerns
  - Hexavalent Chromium
    - Highly Toxic, Carcinogenic
  - Exposure limits set by OSHA. 2/06
    - Can not release dust, fumes or mists from the operation.
    - Permissible Exposure Limit (PEL) of 5.0 $\mu g/m^3$
      - Maximum allowable 8 hour concentration exposure.
      - Air samples must be taken during working hours.
- FDA has set restrictions on emissions through water and air.
  - Hexavalent chromium is extremely mobile and travels into the water tables very easily.

Diagram of Plating Tank

- Hexavalent chromium (Cr^{+6}) is plated onto workpiece with a reduction.
- A catalyst initiates this process. At the end of the reduction, only pure chromium (Cr^{+0}) is plated onto the workpiece.
- Solution is a mixture of (99%>)hexavalent and (1% or less) trivalent chromium. The work piece is the only point where chromium is fully reduced.

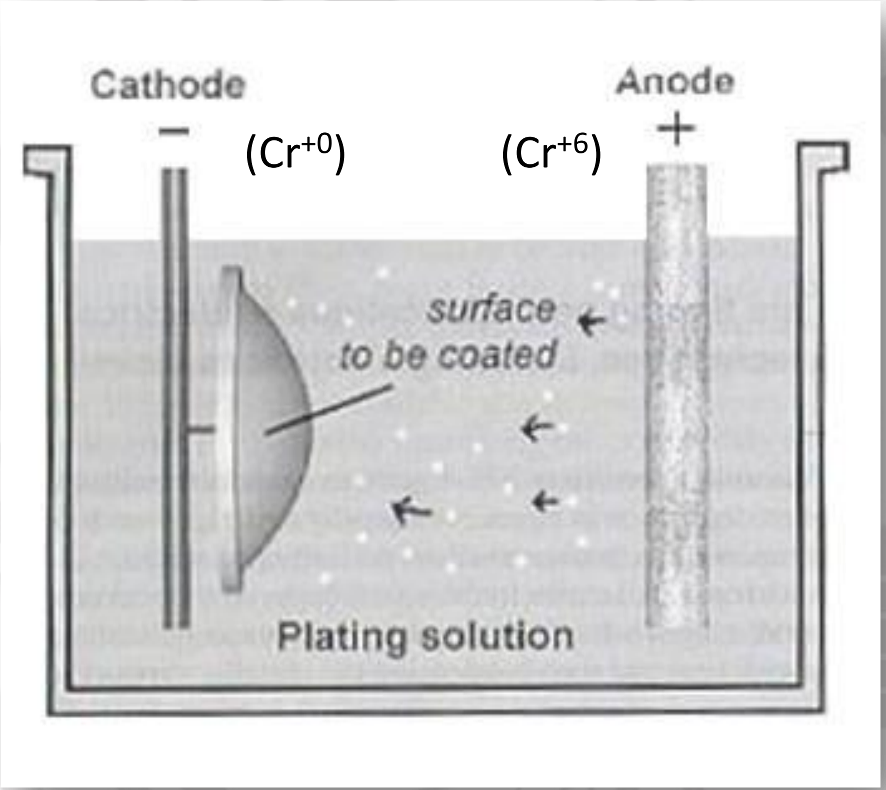

Image Source: Swicofil AG Textile Services
Site: http://www.swicofil.com/textile_metallization.html
Retrieved (2/26/10).

Hazardous Waste Remediation

- Investigated switching to alternative process.
  - No process will fit the requirements of the products plated in an economical manner at this time.
- Developed the root causes for hazardous waste disposal.
  - 1st Source: Plating bath is contaminated and no longer plates out onto parts.
    - Three sources of contamination.
      - Hexavalent chromium is reduced to trivalent chromium.
      - Mineral contamination from the water source.
      - Dirt and Iron from the plated workpieces.
  - 2nd Source: Degraded rubber tank liners, wood framing from tanks and clean up supplies are contributors to solid waste that is contaminated by chromic acid.
    - All waste needs to be sent to the same hazardous waste facility.

Re-oxidation of Trivalent Chromium

- Electrolytic separation is the best option for small plating systems.
  - Typically these units are called porous ceramic diaphragms.
  - Applying a current from a rectifier allows metallic contaminates to accumulate within the ceramic pot.
    - This waste can be collected in sludge form or plated to the cathode.
    - Simultaneously, the trivalent is re-oxidized at the anode of the device.
      - Further ensuring solution life.

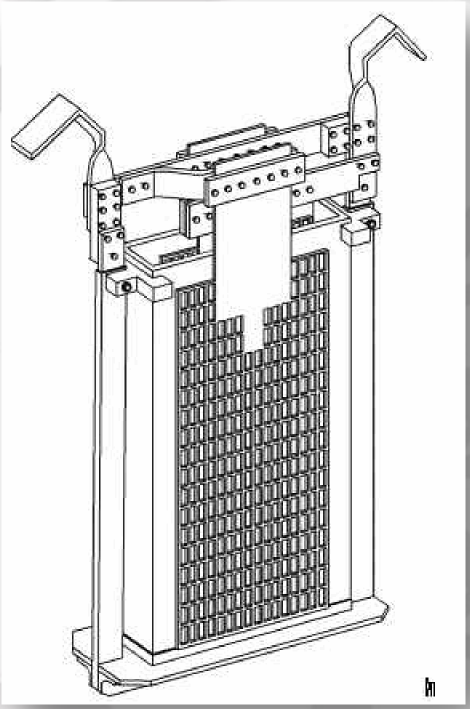

Image Source: Hard Chrome Plating Consultants, Inc. (2010)
Site: www.hard-chromesystems.com (Retrieved 4/22/10)

Solid Wastes

- Rubber tank liners are constructed of PVC.
  - Oxidation 'liquid-line' causes PVC to breakdown.
    - Current life of the tank liners is 1.5-2 years before replacement.
    - Disposed with hazardous waste.
- Framework of tank and air scrubber hood is made of wood currently.
  - The chromic acid often causes the wood to breakdown and results in replacement on a biyearly basis.
    - Wood sent to hazardous waste.
- Towels, paper, cardboard, etc. to clean up chemical spills and drip from pulling parts from the solution.
  - All these supplies sent to treatment facility as well.

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PVC Liners w/ Teflon Skirt

- Increases the life of a liner from 1.5-2 yrs to 6-7 yrs.
  - PTFE or Teflon barrier prevents oxidation of liner at the surface.

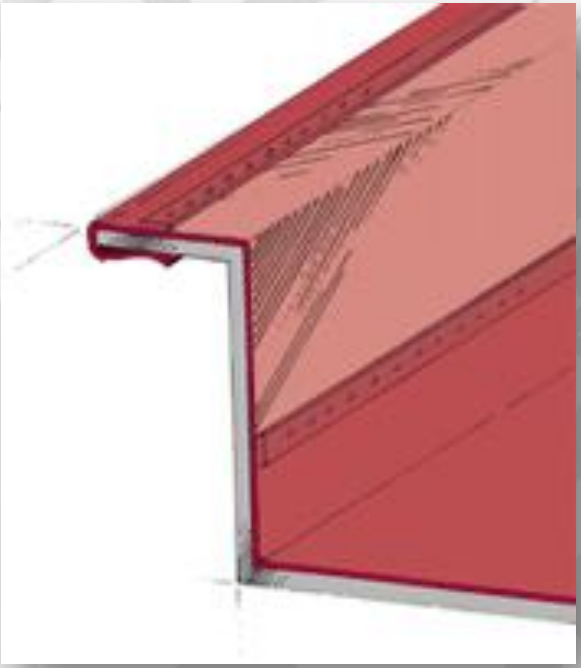
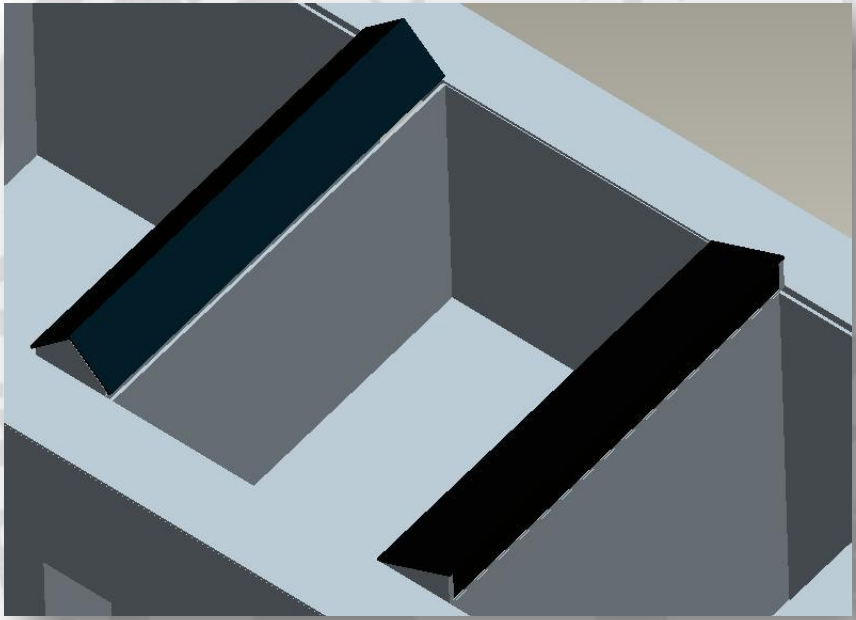


Image Source: Witt Lining Systems (2010)
Site: http://wittliners.com/chromeplating.asp Retrieved 4/23/10

New Work Station

- Incorporation of drip guards between tanks.
  - Removable and easy to clean.
  - Made from PVC or PTFE depending on service life desired.
  - All chrome acid feeds back to plating tanks with design.



Conclusions

- Reduced the amount of hazardous waste by 97%.
  - Payback of approximately 1 year.
- Provided data to reduced the size of the operation by 1/3 to improve energy efficiency.
- Provided a plan to optimize heating of the solution with batch schedule.

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Alternative Processes

- Currently we are investigating economical and environmentally sustainable alternatives to hexavalent chrome plating.
  - Trivalent chrome
  - HVOF thermal sprays
  - Electroless nickel
  - PVD and CVD coatings

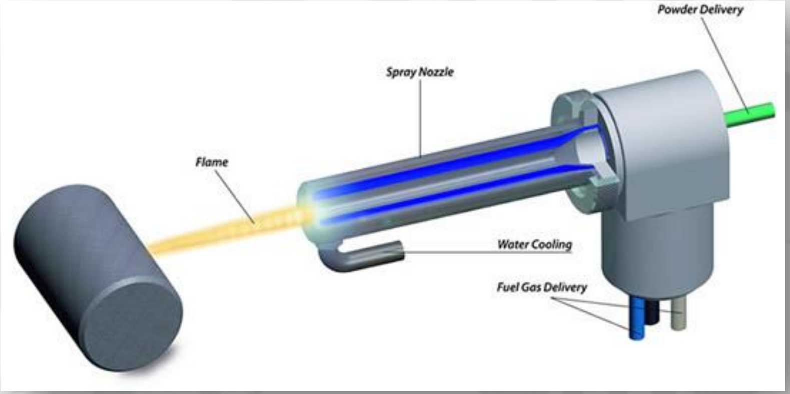

Image Source: Deloro Stellite, "HVOF- High Velocity Oxy Fuel" (2010).
Site: www.stellite.co.uk/.../tabid/76/Default.aspx (Retrieved 2/24/10).

Image Source: PVD, " An example of a PVD vacuum coating machine, (2010).
Site: http://www.pvd-coatings.co.uk/coating-machine.htm (Retrieved 2/24/10).

Current Projects

- Powder Coating
  - Spray-to-Waste minimization.
- Waste-to-Energy
  - Another food waste project.
- Site Assessment Tool Development

Contacts & Progress Reports

- Want more information about the consortium?
  - Carey Schoolmaster, Program Coordinator
    - carey.schoolmaster@wmich.edu
- See our updates and progress via "Green Scoreboard" on our website at http://www.wmich.edu/mfe/mrc/greenmanufacturing/

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Green Scoreboard			
Investments	Annual Savings	Return on Investments	Potential Jobs Created
$2,361,600	$3,163,253	6.5 months	73

QUESTIONS OR COMMENTS?

THANK YOU FOR YOUR TIME.